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Optimal Power Flow Solution using GBest-ABC

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Abstract: This paper presents the load flow solution using GBest-ABC nature inspired algorithm. Load flow solutions are needed for planning and operation of power system. The Newton-Raphson (NR) method is generally used to solve load flow equations but NR method has some drawbacks to solve large and complex network. Hence, in this paper GBest-ABC algorithm is implemented on IEEE 5-Bus and 30-Bus system and Reported results are fairly accurate and completive to NR Method.

Keywords: Load Flow, ABC, Nature Inspired Algorithm, GBest

I. INTRODUCTION

Load flow solutions are needed to calculate power flow in various line segments, various buses and power generation by generator. Power flow analysis was design by using numerical analysis or methods to solve the problem for interconnected power system.. The load flow equations, which are non linear in nature, are generally solved by Newton Raphson, Gauss Siedel and Fast Decoupled methods [1]. The most popular is known as Newton Raphson method. The Newton-Raphson power flow method involves the formal application [2-3] of a well-known general algorithm for the solution of a set of simultaneous nonlinear equations $f(x) = 0$, where f is a vector of functions $f1 \cdots fn$ in the variables $x1 \cdots xn$. This technique follows from a Taylor series expansion of $f(x) = 0$, i.e., $f(x+\Delta x) = f(x) + J(x)\Delta x$ + higher order terms where $J(x) = \partial f/\partial x$ is the square Jacobian matrix of f(x), with $Jik = \partial fi/\partial xk$. In developing the solution technique, the higher order terms are neglected and equation is solved iteratively. Defining $\Delta xp := xp+1 - xp$, can be rewritten for the (p + 1)th iteration as $f(xp + \Delta xp) = f(xp) + J(xp)\Delta xp$.At each step in the iteration process, the value of Δxp which makes $f(xp+\Delta xp) = f(xp+1) = 0$ is determined. Hence at each iteration of the Newton-Raphson method, the nonlinear problem is approximated by a linear matrix equation. To use the algorithm for power flow solutions, it is merely required to write the equations defining the power flow problem as a set $f(x) = 0$. The Newton-Raphson algorithm can only handle real equations and variables, so the complex equations are split into their real and imaginary parts, and the voltage variables are taken as V and θ. Researchers are continuously working to improve the accuracy of load flow problem solutions [4-6] .Meta-heuristic search methods and nature inspired algorithms have also been applied to solve the load flow and parameter estimation problems [7-9]. In this paper, swarm intelligence based algorithm GBest artificial bee colony [10-11] algorithms has been used to solve load flow problem of 5-bus and 30-bus networks. It is shown that GBest ABC algorithm gives better result than NR method.

II. GBEST-ABC ALGORTHIM

GBest-ABC algorithm is an improved abc algorithm by incorporating the information of global best (GBest) solution into the solution search equation to improve the exploitation which is proposed by zhu and kwong [11] in 2010. The honey bees are classified into three groups' onlooker bees, employed bees and scout bees. The numbers of employed bees are equal to the onlooker bees. The employed bees are which search the food source and gather the information about the quality of the food source. The scout bee, searches new food sources randomly in place of the abandoned foods sources. Similar to the other population-based algorithms, abc solution search process is an iterative process. After, initialization of the abc parameters and swarm, it requires the repetitive iterations of the three phases namely employed bee phase, onlooker bee phase and scout bee phase. The flow chart of abc algorithm is shown in Fig.1. GBest ABC is inspired by PSO [12], which, in order to improve the

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exploitation, takes advantage of the information of the global best solution to guide the search by candidate solutions. They modified the solution search equation of Gbest ABC as follows:

$$v_{ij} = x_{ij} + \phi_{ij}\left(x_{ij} - x_{kj}\right) + \psi_{ij}(y_j - x_{ij}) \quad (1)$$

where the third term of equation (1) is a new added term called gbest term, yj is the jth element of the global best solution ,ψij is a uniform random number in [0,C], where C is a non negative constant. According to equation (1), the GBest term can drive the new candidate solution towards the global best solution; therefore, the modified solution search equation described by equation (1) can increase the exploitation of ABC algorithm. The steps of GBest-ABC is shown in Fig.1.

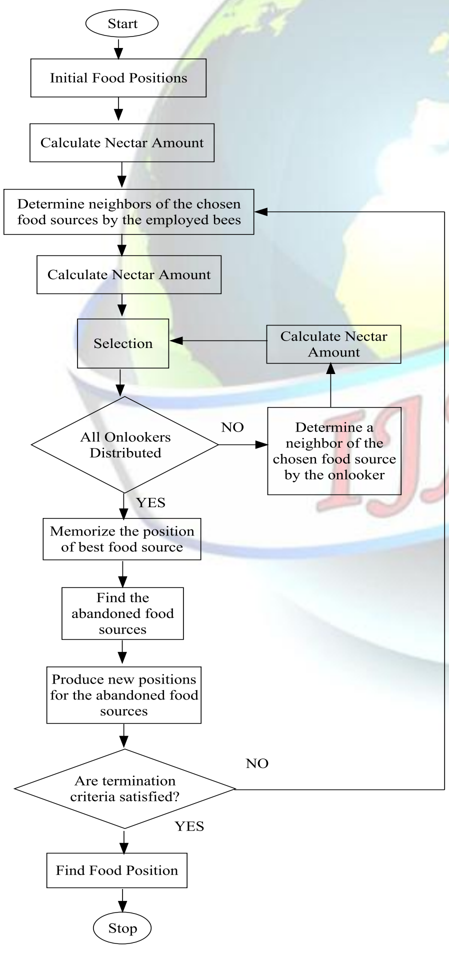

Fig. 1 Flow Chart of ABC Algorithm

III. PROBLEM FORMULATION

Load flow equations is a power balance equations at each bus for both active and reactive powers. As per power balance equations, there should not any power lose in any bus i.e. input power to a bus equals the output power from that bus. The objective of the load flow studies is to solve voltage magnitudes and angles of different system buses, minimizing the difference between input/output powers of the bus. Therefore, load flow problem can be formulated as an optimization problem. In this paper, the load flow problem has been solved by considering a single phase model and assuming it to operate under balanced condition for four associated quantities with each bus viz. voltage (V), phase angle (δ), real power (P) and reactive power (Q). This is also an optimization problem and can be solved for minimum value of objective function given as [13-14]:

$$H = \sum_{i\in n_{PQ}+n_{PV}} \left|P_i^{sp} - P_i\right|^2 + \sum_{i\in n_{PQ}} \left|Q_i^{sp} - Q_i\right|^2 + \sum_{i\in n_{PV}} \left|V_i^{sp} - V_i\right|^2 \quad (2)$$

where, n_{PQ}, n_{PV} are the total numbers of PQ and PV nodes.

IV. RESULT ANALYSIS

Case study is implemented on two test system IEEE 5 and 30 bus systems. Results show that the bus voltage for ABC and GBest ABC has approached more accurate solutions as compared to NR method for the problems of 5 Bus (Table 1) and 30 Bus (Table 2) system. Line losses (Table 3) in terms of active power and reactive power losses are also lower for GBest ABC as compared to NR and ABC method. Thus it is obtained that generated power by GBest ABC is more reliable for a balanced network. Results obtained for 30-bus (Table2) in terms of voltage magnitude (V) and angle (δ) are more promising to NR method. So, the results show that GBest ABC can be considered a competitive method for solving load flow problems.

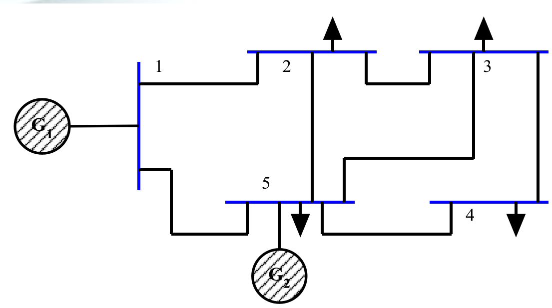

Fig. 2. 5-Bus System

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TABLE 1

RESULT OF 5-BUS PROBLEM

Bus No.	NR		ABC		GBEST ABC	
	Voltage Magnitude (pu)	Angle (deg)	Voltage Magnitude (pu)	Angle (deg)	Voltage Magnitude (pu)	Angle (deg)
1	1.05	0.000	1.05	0	1.05	0
2	0.9826	– 5.0124	0.98554	-6.28181	0.984571	-5.01865
3	0.9777	– 7.1322	0.991387	-11.2626	0.980781	-7.12979
4	0.9876	– 7.3705	1.004046	-10.8028	0.991064	-7.30659
5	1.02	– 3.2014	1.027102	-5.03639	1.02519	-3.24332

TABLE 2

RESULT OF 30-BUS PROBLEM

Bus No.	NR		ABC		GBEST ABC	
	Voltage Magnitude (pu)	Angle (deg)	Voltage Magnitude (pu)	Angle (deg)	Voltage Magnitude (pu)	Angle (deg)
1	1.06	0.000	1.06	0.000	1.06	0.000
2	1.043	-5.3474	0.980001	-12.256	0.980001	-5.1256
3	1.0216	-7.5448	0.97051	-14.3645	0.980001	-8.6345
4	1.0129	-9.2989	0.982305	-15.6426	0.989105	-8.7956
5	1.01	-14.1542	0.98427	-19.7854	0.9977	-14.7854
6	1.0120	-11.088	1.01	-16.6432	1.020195	-12.6743
7	1.0034	-12.8734	1.0705	-13.458	1.001705	-14.4598
8	1.01	-11.8039	1.0336	-16.1274	1.079436	-11.6076
9	1.05	-14.1363	0.98643	-19.5432	0.991268	-13.8754
10	1.0437	-15.7341	0.99048	-21.645	0.985058	-17.5346
11	1.082	-14.1363	1.0342	-19.498	1.077997	-13.6389
12	1.0576	-15.7341	0.97643	-22.5103	0.982407	-15.6504
13	1.071	-14.1363	1.03265	-23.0427	1.092243	-13.0634
14	1.0428	-14.9416	1.0268	-24.134	1.015486	-15.0214
15	1.0384	-14.9416	1.0499	-23.2642	1.019499	-13.0432
16	1.0445	-15.8244	1.0012	-24.6432	1.004428	-15.3276
17	1.0386	-15.9101	0.980153	-19.1865	0.996646	-17.1073
18	1.0281	-15.5487	1.0475	-18.9864	1.058035	-14.0967
19	1.0252	-15.8856	1.03286	-15.0133	1.058316	-16.5093
20	1.029	-16.5425	1.0016	-25.1121	1.048106	-15.8506
21	1.0292	-16.2462	1.01234	-19.2453	1.012617	-17.9465
22	1.0353	-16.0738	1.01027	-23.0132	1.027024	-15.0542
23	1.0291	-16.2528	1.0163	-26.124	1.020145	-18.2974
24	1.0237	-16.4409	1.0118	-19.128	1.041228	-17.4128
25	1.0202	-16.0539	1.01345	-22.1923	1.035245	-15.4519
26	1.0025	-16.4712	1.04334	-23.4671	1.09044	-15.4671
27	1.0265	-15.558	0.97002	-15.6385	0.980002	-16.6385
28	1.0109	-11.7436	1.01219	-19.3693	1.031919	-12.8593
29	1.006	-16.7777	1.0132	-23.6567	1.034912	-15.4367
30	0.9953	-17.6546	1.0127	-22.865	1.033927	-18.9845

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TABLE 3

LINE LOSSES

Test System	NR		ABC		GBEST ABC	
	Active Power Loss (MW)	**Reactive Power Loss (MVar))**	**Active Power Loss (MW)**	**Reactive Power Loss (MVar))**	**Active Power Loss (MW)**	**Reactive Power Loss (MVar))**
5-Bus	4.101	18.503	3.952	18.476	3.402	18.107
30-Bus	17.528	68.888	17.512	68.853	17.236	68.324

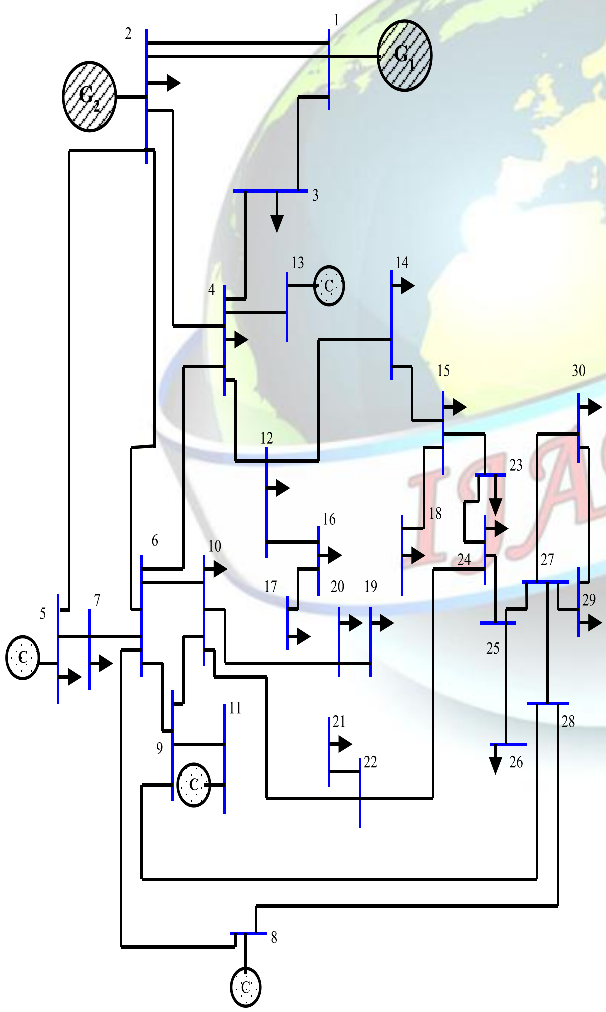

Fig. 3. 30-Bus System

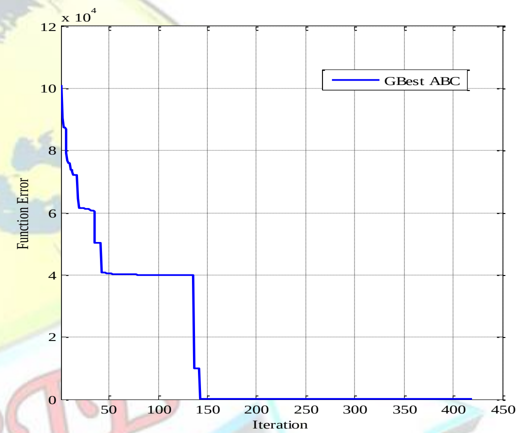

Fig. 4 Convergence Curve for 5-Bus

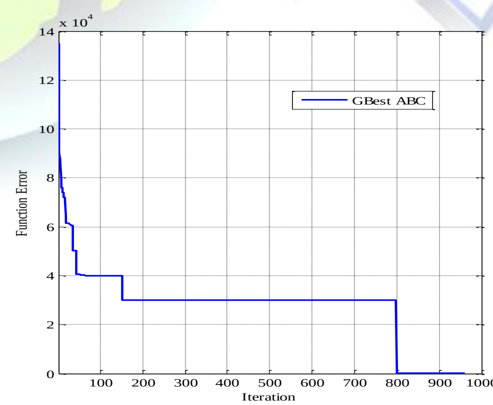

Fig. 5 Convergence Curve for 30-Bus

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Fig.4 and Fig 5 show the convergence curves for 5-bus and 30-bus for wheeling charges. It is observed that the obtained curves are fairly accurate and evenly varying.

V. CONCLUSION

This paper has analyzed optimal load flow solution for IEEE 5-bus, 14-bus and 30-bus test system using GBEST ABC method. The obtained results has reveled high efficiency and accuracy of proposed method. Voltage profile has been found to improve as compared to conventional NR method. The line losses have also reduced for GBest-ABC method as compared to NR method. As the analysis this algorithm does not dependent on initial values, it can be implemented for large, abnormal and complex networks. The computation time has been found higher as compared to NR method and accounts to improve in order to make GBest ABC method more time efficient. The results thus obtained are more suitable and valid for the proposed algorithm as a new tool for load flow solution to solve problems encountered due to Jacobian singularity in the classical techniques. Hence, overall performance of proposed algorithm is effective and efficient for large and complex networks.

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